





ment, energy prospecting activities, and declining agricultural operations are now being compounded by the regional effects of global-scale climate change. As the 21st century progresses, alpine aquatic and riparian resources will be increasingly impacted by warmer air/water temperatures, earlier spring runoff, shifts in species composition, and altered soil moisture and precipitation patterns (such as more precipitation falling as rain vs. snow). The combination of natural variability with human-induced climate change will likely alter water supply and demand in ways new to existing institutions and legal structures such as the Colorado River Compact (the Compact, originally signed in 1922, is an interstate agreement that allocates the Colorado River's water among the seven southwestern U.S. states). Climate change will additionally impact human uses of local water resources from irrigation and municipal supply to hydroelectricity generation and recreational uses such as snowmaking, boating, and fishing. Traditional management and legal agreements need to be modified to accommodate these new factors.

## Recommendations for Next Steps

Improved understanding of the risks associated with climate change can lead to adaptations that are anticipatory rather than reactive. Apart from the impacts of local change, the Roaring Fork Watershed is now responding to global forces that are external to local jurisdictions and institutions. This creates new challenges for local resource managers and planning efforts, and will likely force a re-evaluation of management practices. Key recommendations from Chapter 3.5 for incorporating climate change into watershed management plans include:

1. The initiation of an integrated assessment incorporating hydrological and regional climate modeling is needed to develop more complete understanding.
2. Water management plans should not be considered complete without provisions for climate change-driven impacts and adaptations.
3. River related infrastructure projects should incorporate future projec-

tions of streamflows based upon climate change research and should not rely solely on interpretation of historical flow/variability.

4. Research to assess the impact that significant global warming may have on present economic trends (real estate, tourism, recreation, and energy) should be undertaken.
5. Site-specific research and monitoring is needed to better understand the complex watershed interactions at work and improve projections of system-wide impacts and adaptive responses.
6. A re-examination of the legal framework of water allocations is needed to identify ways in which existing rights may be legally altered in anticipation of new threats from increased demand and altered streamflow as a result of climate change.

## Developing a Dynamic Implementation Strategy

Although the State of the Watershed report is an important first step, an in-depth integrated climate impacts assessment utilizing recent developments in regional climate and hydrologic modeling could help identify and quantify potential vulnerabilities beyond the more qualitative assessment provided in Chapter 3.5. The many interconnected variables at play in the Roaring Fork Watershed require a systems analysis approach to assess future threats and opportunities for preemptive action, along with active stakeholder involvement to help guide policies and procedures. One innovative example of this type of approach was conducted by Cohen and Neale for the Okanagan region in British Columbia. The approach engages stakeholders with local experts and scientists to develop adaptation strategies. The general framework combines climate change scenarios, hydrological scenarios, and water supply and demand scenarios, along with adaptation studies and dialogue with stakeholders (Cohen and Neale, 2006). A proposal for such an assessment for the Roaring Fork Watershed is currently in the exploratory stage. At the state level, the Colorado

Water Conservation Board has initiated a climate/hydrologic modeling study to provide water managers with future water availability estimates.

Adding human-induced climate change to the list of critical factors addressed in traditional watershed assessments and management plans is essential for devising sound strategies for watershed management in the future. As we move further into the 21st century, the challenge will be to identify and quantify potential vulnerabilities in advance so that adaptations can be built into the planning process, thereby reducing vulnerability and increasing resiliency to the impacts of change.

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## Weblinks

State of the Roaring Fork Watershed Report: <http://www.roaringfork.org/sitepages/pid272.php>

Aspen Global Change Institute: <http://www.agci.org>